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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Hockey Stick

(72) Motley, Geoffrey P. - Australia ;

(73) Motley Manufacturing Agencies Pty. Ltd. - Australia ;

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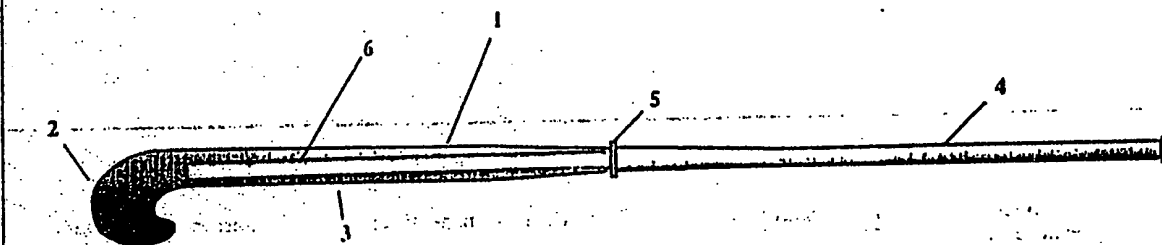
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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/AU90/00582 (22) International Filing Date: 7 December 1990 (07.12.90)  (30) Priority data: PJ 7890                      15 December 1989 (15.12.89)    AU PJ 9214                      19 March 1990 (19.03.90)        AU PK 1807                      17 August 1990 (17.08.90)      AU  (71) Applicant (for all designated States except US): MOTLEY MANUFACTURING AGENCIES PTY LTD [AU/ AU]; Giles & Giles, 68 Greenhill Road, Wayville, S.A. 5034 (AU).  (72) Inventor; and (75) Inventor/Applicant (for US only): MOTLEY, Geoffrey, Pe- ter [AU/AU]; 8 Beattie Avenue, Glenalta, S.A. 5052 (AU).	(74) Agent: COLLISON & CO; 117 King William Street, Ade- laide, S.A. 5000 (AU).  (81) Designated States: AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE (European patent), DK (European patent), ES (Euro- pean patent), FI, FR (European patent), GA (OAPI pa- tent), GB (European patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (Euro- pean patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, RO, SD, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.  Published With international search report.	

## (54) Title: HOCKEY STICK



## (57) Abstract

A hockey stick (1) comprised on a head (2), a stem (3), a handle (4) and a bead (5) showing a division between the parts 3 and 4. The stem (3) includes a slot (6) substantially between the bead (5) and the head (2). The hockey stick is formed by injection moulding a foamed thermoplastics material, usually glass fibre reinforced nylon, such that the density through the head and stem is greater in an outer skin region than in a region contained by the outer skin. The foamed thermoplastic material is formed by the inclusion of a foaming or blowing agent within the plastic material before injection into the mould and the foamed plastics material is held under substantive pressure which is inherently lessened upon release into the mould. The glass fibre reinforcement has an average length of 8 mm and comprises 80 % of the weight of the fibre reinforced plastics material. The quantity of foaming agent is sufficient to reduce the weight of the foamed plastics material to 80 % of that which would be the case if not so foamed.

## HOCKEY STICK

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This invention relates to both a method of manufacture of a hockey stick and to a hockey stick of different construction.

Historically, hockey sticks have been manufactured from wood by a process involving a substantial degree of hand carving. Hitherto there has not appeared to be any reasonable method of manufacture or material from which hockey sticks can have been made which would satisfy the conditions for first class play.

10 It has been known that there could be economic value in manufacturing a hockey stick from plastics materials where the plastics materials are injection moulded into a shape of the stick and in which the plastics material is substantially solid and can be variously chosen from one of the more common plastics such as polypropylene or nylon.

15 Unfortunately, such hockey sticks as have been made, have not been accepted for all classes of play for the game of hockey for technical reasons relating to difficulties pertaining to abrasion resistance, flexibility, density, strength and distribution of weight.

20 The problem with such previously manufactured hockey sticks from such plastics materials is that they have been inherently too heavy and there has been quite literally enormous amounts of effort and time involved in trying to find a solution which can provide for a hockey stick which not only can be  
25 manufactured reliably within a range of weights by a technique such as injection moulding but that any such product manufactured in accord with appropriate dimensions, will have the required three characteristics namely ability to resist abrasion on appropriate faces, a balance of parts that weigh appropriate amounts so that the balance of the stick once manufactured is appropriate for a  
30 player, and finally the flexibility and strength of the final product is appropriate and preferred for the application.

It has been discovered that some characteristics of the shape of the stick can be modified in order to assist in overcoming these difficulties and this has been the  
35 subject of earlier patents.

In an earlier patent application, Australian Patent Application Number 34137/78 we have proposed such a hockey stick in which there is a groove extending along the back of the stem which has provided some assistance in providing better flexural characteristics with better weight distribution.

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The problem with such an arrangement however is that there are no easy means by which any of a smaller number of such sticks can be balanced for individual users. Also, it has been very difficult to provide a hockey stick which will have an appropriate "feel" which is of course a combination of balance and

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flexural characteristics.

The object of this invention then, is to provide for a hockey stick made from moulded plastics material which addresses the problems discussed above.

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According to one form the invention can be said to reside in a hockey stick consisting of a head, a stem, and a handle comprised primarily of moulded plastics material manufactured as an integral whole or as a plurality of parts wherein at least two regions of the said hockey stick are characterised by each being of a different density one from the other and in which the density through

20

the head and through the stem is characterised by being of greater density in an outer skin region than in a region contained by the outer skin.

In preference, the invention can be characterised by one or more grooves in the rear of the stem.

25

In preference, the groove or grooves are each of 'U' shaped cross-section with a long axis of the groove running parallel to a long axis of the stem of the hockey stick.

30

It will be recognised that the groove or grooves may be moulded into the stem of the hockey stick at the time of moulding or may be incorporated later by using mechanical means such as milling.

In preference, the grooves are moulded in the stem of the hockey stick.

35

There are a number of examples in which at least two regions characterised by

each being of a different density one from the other may be formed and these will be separately described it being intended not to limit the invention necessarily to any one of these examples.

5 In one example therefore, there is provided a hockey stick made from moulded plastics material in which there is a hollow core at least some part way along the handle of the stick.

10 In preference, the hollow core is contained primarily in the handle of the hockey stick and is coaxial with a long axis of the handle.

In preference, the said hollow core is of substantially circular cross-section.

15 One of the significant advantages of providing a hollow core is that there is now a process and equipment by which a hollow core can be formed in a variety of plastics material mouldings by introducing a gaseous fluid where the moulding process is a plastics injection process.

20 One such process is that involved in the use of an injection moulding apparatus as identified in Australian Patent Application Number 13150/88 entitled Injection Moulding Apparatus by Cinpres Ltd.

25 The discovery has been that the biggest problem encountered thus far, namely the higher density of plastics that can otherwise provide adequate abrasion resistance, flexibility and strength, can be essentially overcome by introducing a gaseous intrusion.

30 A further preferred feature of this present invention therefore is to provide that in the manufacture of a hockey stick by use of injection moulding techniques of plastics material, there is provided the further step of injecting for a selected period during the injection process, a gaseous fluid such that this will form a hollow core within the appropriate handle shape of the stick.

35 It will be recognised that the hollow core may be incorporated into the handle of a hockey stick manufactured as either an integral whole or as a plurality of parts.

There are a number of techniques by which such a hollow core can be effected and at least the method described in the referred to Cinpres Ltd. patent application includes injecting and maintaining the gaseous fluid at pressure during at least part of the moulding and cooling process.

5

In this way, there can be caused an additional compressive force causing advantageous characteristics within the cooling plastics material so that these can be variously more dense which in turn provides a different flexural characteristic.

10

Such advantages follow from the concept of using gaseous fluid at pressure for forming a core within the handle and such gas therefore not only causes such pressure to the cooling plastics between the hollow core and the surface of the mould but also in a continuing elongate direction toward the head of the stick,

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such additional pressure also assists in establishing such a further density and flexural characteristic of this further part of the stick.

20

Because of the overall size of a hockey stick, to propose an individual die for each of a variety of different shapes and sizes of hockey stick for each of a selected type of person, would be essentially prohibitive from a cost point of view.

25

A feature of the technique described is that by introducing the gaseous fluid at a selected interval within a plastics material injection cycle, the length and position of the hollow core can be determined and so that therefore, while the external appearance of any selected hockey stick might be the same as any other, the length and depth of a hollow core can be quite different therefore making one hockey stick feel "heavy" while another might feel "light".

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The ability to provide such a variety and in fact tailor a particular stick to a customer now becomes possible.

35

This description does not extend to specific details of injecting with the plastic injection the gaseous fluid, but it is known and understood that such gaseous fluid is injected at a substantial pressure and there are means subsequently to relieve such pressure either at the same aperture in which the plastics material

is injected or at an aperture formed in some other position.

To this end, there can be provided a plastics injection nozzle injecting plastics directly from an outer most end of the hockey stick shape and means to

- 5 introduce a gaseous fluid some two to three inches down the length of the stick such that during the injection process of the plastics material, the injected gaseous fluid such as a neutral gas such as nitrogen will be caught with the flowing plastics so that as the plastics pass an injection point, the gaseous fluid such as nitrogen or other gas can be injected into a middle area of such plastics
- 10 so that the hollow thereby caused can be carried with the plastics itself.

In a further example, the handle part of a stick is comprised of a moulded shape interlocked with, infused through or surrounded by a further plastics material.

- 15 Such further plastics material providing therefore a bulk by which a handle shape can be provided, can be made from an appropriately foamed plastics material and can be either of a star cross-sectional shape, or the shape can comprise a slot passing through and along the stem shape, or there can be a plurality of circular apertures at spaced intervals along the length of the stem
- 20 shape or there can be other elliptical shapes or rectangular shapes or triangular shapes such shape extending as a constant shape along the length of the handle.

- The purpose of each of the shapes is to provide an integral interlocking strength with the stem and head of the hockey stick and that foamed material provides the interlocking bulk and therefore gripping shape by which the hockey stick can be gripped by a player.
- 25

- In a further example, there is provided a hockey stick made from moulded plastics material which includes an outer skin of plastics material and a core comprised of a foamed plastics material.
- 30

- It will be recognised that the outer skin of plastics material and the core of foamed plastics material may be characterised by being of different chemical composition one from the other.
- 35

In preference, the plastics material of the outer skin of the hockey stick and the foamed plastics material of the core of the hockey stick are of the same chemical composition but are distinguished by being of different density one from the other.

5

In another example, there is provided a hockey stick made from moulded plastics material in which a substantial part of the stick is comprised of a foamed plastics material, the construction being such that such foamed plastics material provides a core and the external surfaces are in the main comprised of plastics material not so foamed.

10

In preference, the outermost skin of the stick has a more dense skin around the head and lower body part and a less dense skin at an upper part of the handle of the stick.

15

A major problem with developing a hockey stick made from plastics material is that conventional materials provide characteristics which are not entirely suitable to determine appropriate flexural and fracturing characteristics and it has been found that a preferred arrangement is to provide for fibre reinforced plastics materials to be used for the moulding of such a hockey stick.

20

In preference, the plastics material is reinforced with randomly oriented fibre reinforcement which, in preference, is comprised of glass fibre.

25

In preference, the length of the reinforcement lies within the range of 1 mm to 20 mm although in preference it is approximately in the range of 4 mm to 12 mm and in preference is 8 mm on an average length.

30

In preference, the proportion by weight of such reinforcement is approximately 60-90% of the total weight of plastics material and more preferably 80%.

35

In preference, the quantity of foam to cause a core of foamed plastics material is such that the weight of the plastics material is reduced to 80% of that which would be the case if the plastics was solid.

In a further form of this invention, this resides in the method of manufacture of a



hockey stick which comprises the steps of forming by injection moulding a hockey stick comprising the steps of injecting into a mould a foamed plastics material.

- 5 In explanation here, the technique for forming such a stick does involve the inclusion within the plastics material before injection into the mould, of an effective foaming agent which is held under substantive pressure which is inherently lessened upon release into the injection mould.

- 10 It is this foaming characteristic which is being used to create advantageous features in the characteristics of the stick thus made.

In preference, the foamed plastics is gated into the injection mould at a location which comprises the inner part of the hook shape at the head of the hockey  
15 stick.

- A first characteristic of injection at this location is that the area of the skin immediately surrounding and at the gate location is slightly more porous but as this is not a surface area that will be subject to abrasion, this is then an  
20 appropriate location in this vicinity.

- However, those areas of the skin which are slightly displaced from this location that is the hitting face of the head or hook and perhaps most importantly the underneath side of the head or hook all take the first slug of injected foaming  
25 plastics material and there is formed thereby a substantive thickness at good or high density in these vital locations.

- In the injection process however as the injected foaming plastics proceeds up the die toward the handle, more of the foaming material under the confining  
30 pressure is somewhat more released because of the somewhat open area into which the plastics is being injected so that as a matter of time, that plastics material which reaches the last or most distant parts of the die becomes more porous especially at the surface area and it is this characteristic that is an acceptable characteristic at the handle end where surface abrasion is no  
35 longer a problem and some surface porosity is not disadvantageous in providing for adhesion of a surrounding grip material.

5 Some of the more difficult problems related to providing a hockey stick which can be suitable for the highest international class of playing of the game, include its stability when being subjected to ultra violet light, its resistance to changing conditions of temperature and humidity, and finally its abrasive resistance.

10 It will be self evident that if a hockey stick of this type will change its flexural characteristics significantly simply because it is going to be used on a warmer day or a colder day, then of course, it has much less value than might otherwise be the case.

15 A discovery of this invention has been that there is a material which can provide significant answers to these further problems.

This in specific terms is a long glass fibre reinforced nylon type product.

20 Nylon has the significant advantage that it will absorb water and this has as its main influence an increasing of ductility of the material which therefore effectively increases impact strength while at the same time reducing flexural strength and modulus.

25 It is in fact therefore of advantage that a product made using such a material should be immersed and preferably boiled in water for a significant period so as to ensure a total take-up of water before commencing use.

30 A specific material that is considered to be of significant value to the present proposals is a long glass fibre reinforced nylon 66 which is presently being offered for sale by ICI Plastics of Stanford Street, Ascot Vale, Victoria 3032, Australia under the trade mark "Verton".

35 One of the significant advantages of using such a material relates to the mode of any fracture that might be caused so that if in fact the stick was broken under fracture loadings, it can be expected that any fracture edges will not be spear-like as might be the case with continuous rovings so that in the vigorous game of hockey, such hockey sticks can be considered somewhat safer than previous

design proposals.

For a better understanding of this invention it will now be described with reference to the preferred embodiments it being emphasised that it is not intended that the invention should be necessarily limited to the specific article being described.

In the description reference shall be made to drawings wherein:

FIGURE 1 is a side view of a hockey stick of existing design,

FIGURE 2 shows one embodiment of a handle,

FIGURE 3 shows a second embodiment of a handle,

FIGURE 4 shows a cross-sectional view of the stem of a hockey stick showing in particular a groove in the rear of the stem,

FIGURE 5 is a cross-sectional view of the hockey stick manufactured in accord with the method of the embodiment,

FIGURE 6 is a cross-sectional view along the lines 6-6 in Figure 5, and

FIGURE 7 is a cross-sectional view along the line 7-7 of Figure 5.

Referring to the drawing, the hockey stick 1 is comprised of a head 2, a stem 3, a handle 4 and a bead 5 showing a division between the parts 3 and 4. The stem 3 includes a slot 6 substantially between the bead 5 and the head 2.

The reference to "hockey stick" therefore presumes that all the criteria useful for the playing of hockey are met.

The factors that have to be considered in relation to the overall design comprise the outside diameter of the handle, the ability to core the handle using either gaseous injection or foaming materials, a change in the groove in the back of the stem part of the stick and a change in the overall head mass to reduce

weight.

As a first embodiment, a solid hockey stick was moulded using the referred to Verton material produced by ICI and being type RF700-10EM this being a 50 percent long glass reinforced nylon 66 material.

Such a material has a specific gravity relative to water of 1.57 the length moulded was 940 mm, the volume was 546,103 cubic mm, the weight was 856 grams (30.2 ozs), maximum stress under an arbitrary 200 Newton force applied at 860 mm from a rigidly fixed handle end comprised 127.3 Mpa and a maximum deflection of 11.4 mm.

At a total weight of 30.2 ozs, this hockey stick, while useful for some players, was not satisfactory for normal play by competition players recognising that a weight of something between 17 to 27 ozs was necessary.

#### Handle Analysis - Cored Handle

The handle of most hockey sticks is the area of least stress in a normal game of hockey. As in the game of golf, the head of the stick does most of the work and is subject to the majority of abuse in a normal game. Players of hockey generally wrap towel binding around the outer handle of the stick to provide adequate grip and "feel". Provided the outer diameter of the handle remains inside a 50 mm diameter ring gauge there are no specific size requirements. As a result of this we have examined ways to core out the handle area to reduce weight and to shift the centre of gravity towards the striking area of the stick.

The standard handle diameter is 20 mm and covers a distance of 360 mm on a 940 mm (37") stick. We cored the handle using a gas injection system marketed in Australia by ICI (Embodiment 1). This system identified by the Registered Trade Mark, "Cinpres" allows solid regions to be cored using a gas which is injected at the same time as the thermoplastic resin. The analysis looked at the effect of introducing a hole over a distance of 460 mm into the handle region of the stick. Various diameter holes were examined as well as slightly increasing the outer diameter of the handle to 21 mm to see the effect on the strength and deflection of the handle area (Embodiment 2). The results for embodiments 1

and 2 are shown in Tables 1 and 2 respectively. In each case the stress and deflection are measured under a 200 Newton Force applied at 860 mm from a rigidly fixed handle end.

5 Table 1 - Embodiment 1

	Handle Dia (mm)	Hole Dia (mm)	Weight Red'n (ozs)	Total Wt. (ozs)	Wall Thick. (mm)	Stress (MPa)	Defl'n (mm)
10	20	0	0	30.2	10	127.3	11.4
	20	5	0.5	29.7	7.5	127.8	11.4
	20	8	1.3	29.0	6	130.7	11.7
	20	10	2.0	28.2	5	135.8	12.1
	20	12	2.9	27.4	4	146.3	13.1
15	20	14	3.9	26.3	3	167.6	15.0
	20	15	4.5	25.7	2.5	186.3	16.6
	20	16	5.1	25.1	2	215.7	19.3

Table 2 - Embodiment 2

	Handle Dia (mm)	Hole Dia (mm)	Weight Red'n (ozs)	Total Wt. (ozs)	Wall Thick. (mm)	Stress (MPa)	Defl'n (mm)
20	21	0	-0.8	31.1	10.5	104.7	9.4
	21	5	-0.3	20.6	8	105.1	9.4
	21	8	0.5	29.8	6.5	107.0	9.6
25	21	10	1.2	29.1	5.5	110.4	9.9
	21	12	2.1	28.2	4.5	117.3	10.5
	21	14	3.1	27.1	3.5	130.5	11.7
	21	15	3.7	26.6	3	141.6	12.6
	21	16	4.3	25.9	2.5	158.0	14.1

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#### Handle Analysis - Laminated Handle

Embodiments 3 and 4 involved examining the use of two polymeric materials in the handle area. The intention was to mould a slot in the handle made from material identified by the Registered Trade Mark "Verton", and as a second

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operation, insert mould a low density foamed polymeric material into the slot area. This would have two effects:

- a) Lower the weight of the handle area
- b) Act as a shock absorbing medium to reduce jarring.

With reference to Figure 2, Embodiment 3 consisted of a 20 mm handle 4 with a 10 mm slot 7 and Embodiment 4 consisted of a 21 mm handle 4 with an 11 mm slot 7.

Table 3 shows the results of the modifications.

Table 3 - Embodiments 3 and 4

Handle Dia (mm)	Slot Width (mm)	Weight Red'n (ozs)	Total Wt. (ozs)	Stress (MPa)	Defl'n (mm)
20	10.0	3.3*	26.9	158.5	14.1
21	11.0	3.5*	27.4	132.7	11.3

\* Note! Includes the addition of a foamed polymeric material with a density of 375 kg/m<sup>3</sup>.

Handle Analysis - Cross Formation Composite

- Embodiments 5 to 7 followed a similar theme to Embodiment 3 in that two materials were considered, one being a material identified by the Registered Trade Mark "Verton" and the other being a low density foamed polymeric material. We used a cross formation centred in the handle region. Foamed polymeric material was moulded over, to interlock with, the cross to provide a soft feel handle which acted to reduce jarring in play. The soft material would completely cover the Verton and could be coloured to provide an aesthetic handle.

- With reference to Figure 3, which shows a cross-sectional view of the handle 4, Embodiment 5 consists of a cross 8 in which both arms 9 have a width of 6.0

mm. Embodiment 6 is similar to Embodiment 4 but the arms 9 are both 4.0 mm in width. Embodiment 7 has one arm 9 of 6.0 mm and one arm 9 of 4.0 mm. In all three embodiments the handle diameter is 20 mm and the cross diameter is 16 mm.

5

Table 4 shows the results of the three Embodiments.

**Table 4 - Embodiments 5, 6 and 7**

Handle Dia (mm)	Embodiment	Weight Red'n (ozs)	Total Wt. (ozs)	Stress (MPa)	Defl'n (mm)
20	5	2.43*	27.77	385.9	43.1
20	6	3.16*	27.04	577.9	64.5
20	7	2.74*	27.46	408.7	45.6

\* Note! Includes the addition of a foamed polymeric material with a density of 375 kg/m<sup>3</sup>.

#### Analysis of Groove on Back of Hockey Stick

In this section we are examining the weight reduction and effect on strength as a result of modifying the groove section down the back of the hockey stick. Each change is treated separately to see the effect on deflection and stress as a result of the change. Embodiment 8 represents the base embodiment to which comparisons are made.

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Referring to the Figure 4, which is a representation of Embodiment 8, the stem 3 is 45 mm wide across the front face 11 and is 20 mm thick from front face 11 to back 12, the groove 10 has a radius of 7.5 mm. The ridges 13 either side of the groove 10 have a flat top 15 with curved edges 16 of radius of 5.0 mm. The curves 14 at either side of the front face have a radius of curvature of 3.0 mm.

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The cross-sectional area is 670.565 mm<sup>2</sup>. The option being examined are as follows:

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Embodiment 9 Remove 1 mm from the front face 11 thereby making the

thickness of the stick 19 mm

Embodiment 10 Move the centre of curvature of the groove 10 towards the front face 11 by 0.5 mm

Embodiment 11 Increase the radius of the groove 10 to 8.0 mm and reduce the radius of the ridges 13 to 4.5 mm

Embodiment 12 As in Embodiment 11 but change the radius of the ridge 13 to 6.0 mm

Embodiment 13 As in Embodiment 12 but change the radius of the ridge 13 to 5.0 mm.

Table 5 shows the results of the proposed changes.

**Table 5**

Embodiment	Area (mm <sup>2</sup> )	Weight Red'n (ozs)	Total Wt (ozs)	Stress (MPa)	Defl'n (mm-4)
8	670.565	0	30.2	59.8	4.6
9	628.226	0.7	29.5	66.9	5.4
10	654.077	0.3	30.0	60.4	4.6
11	632.162	0.6	29.6	63.0	4.8
12	626.215	0.7	29.5	66.8	5.0
13	598.559	1.2	29.0	73.0	5.4

**Analysis of the Head Area of the Hockey Stick**

The head, or contact area of the stick, is the most important part in normal play. The size of this region is kept as large as permitted by the regulations of the game. The proposed design has a bulbous head shape which concentrates weight and the centre of gravity of the stick towards the contact area.

To further reduce weight of the stick it is proposed to remove 1 mm from the



thickness of the head region. This alteration will have no effect upon the stress or deflection of the stick, but will serve to further reduce the overall weight. There is little effect upon the playing characteristics of the stick as the design has seen the movement of the centre of gravity towards the striking face.

5

The net effect of the reduction of 1 mm in the thickness of the blade is a reduction of weight of 0.4 ozs. On its own this would reduce the weight of the standard stick from 30.2 ozs to 29.8 ozs.

- 10 The previously explored Embodiments illustrate the variety of ways in which different techniques can be used in order to achieve the techniques of this invention.

- 15 By combining some of the features of each of the Embodiments, it has been found that a hockey stick having adequate abrasion resistance, effectual characteristics and weight distribution can be achieved which can be in the vicinity of 25 ozs all up weight.

- 20 What has not been described specifically is the additional feature of providing what is generally called structural foam and by providing for a structural foam which is introduced into the core of the remaining part of the hockey stick, an even more significant weight saving can be achieved.

- 25 Further, while reference has been made to a 50 percent long strand glass fibre reinforced nylon 66 material, it is to be clear that there are a number of alternative materials and compositions of material that can be used which can be useful in this application.

- 30 Typically then, we have found that it is still useful and provides significant advantages to use 35 percent long glass reinforced Nylon 66 and 40 percent long glass reinforced polypropylene.

- 35 The extent to which these materials are either individually used or used in combination is a matter of judgement in relation to the ideal conditions for a hockey stick for each individual choice but illustrate the variations that are presently possible.

In moulding trials carried out using structural foam and using the so called Verton material, it has been found that there can be provided an approximate 2.5 to 3.0 mm wall of solid Verton type material on the outside of the hockey stick with a more porous or foamed region of material inside the skin and of course in preference a further cored out section within the handle region.

On testing thus far, the maximum stress value with a typical article in which there is a 200 Newton force applied at a 500 mm distance from a rigid support holding the stem, will be approximately 150 Mpa.

A further preferred embodiment will now be described which incorporates a number of the findings described above.

Referring to the Figures 5, 6 and 7, the hockey stick 1 is comprised of, in conventional manner, a head 2 with a gate location at an inner step part 15.

A handle 4 and a stem 3 are separated by a bead 5.

The shape of the hockey stick at the stem 3, as shown by the cross-section 6-6 and 7-7 in Figures 6 and 7 respectively, includes a slot 6 along the lower part at a back side which extends substantially the length of the stem between the bead 5 and the hook or head 2 to provide additional depth but in accord with a principle the subject of a previous patent.

In the manufacturing process which comprises injecting in an injection moulding process a thermoplastics material, the plastics material is comprised of a plastics material available from the company ICI and similar to that which is sold under the trade mark "Verton (RF-700-10 EM)" with however a reduced long fibreglass content so that the fibreglass total comprises 35% by weight of the total weight of the material. The plastics material is comprised of nylon 66.

The foaming or blowing agent which is used is known as "Hydrocerel" and the quantity of this material is such that the weight of the plastics is reduced subsequent to foaming within the mould to approximately 80% of the total weight.

This of course is varied in accord with the total weight of a stick required and the balance and as with the length of fibre and the very specific characteristics of the plastics material these can be varied within carefully controlled limits.

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The length of the reinforcing fibre is 8 mm and as a part of the injection process, this is injected through a reasonably large gate so that the reinforcing fibre is kept more or less intact so that whereas it is randomly distributed, it is relatively long as compared to other processes and mixtures that may be used.

10

By directing the injecting material at the location which comprises the inner part of the hook at 15, it is found somewhat conveniently that this provides for a very substantive and consolidated skin around those areas in the immediate vicinity of the hook and that as the distance from the injection gate is extended, the skin

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becomes more porous to the extent that the handle area 4 has some visible porosity on the external surface so that perhaps a 60 or 70% of plastics material and reinforcement is the consolidation of the external surface at this area.

20

In the injection process, the plastics material is first prepared and the blowing agent Hydrocerel is mixed and held in a holding container under pressure so that whereas the blowing agent has effected a release of gas pressure, this has not caused any substantive foaming because of the maintenance of the pressure.

25

By injecting then this results in a release of such pressure insofar that there is an air outlet at some parts of the stick mould and the result of the injection process is in accord with the description.

30

The results of the technique are such that for the first time there has been able to be made by the process of injection moulding a hockey stick which provides for an extremely strong surface skin which substantially resists abrasion and therefore provides long life for a purchaser but perhaps even more importantly, the all up weight of a hockey stick which still is within reasonable dimensions of size can be manufactured to be within the range required by international

35

hockey players and in accord with appropriate international rules.

It has been found by slight variations of the amount of blowing agent, that the all up weight of a stick can be varied so that selected weights such as a 21 ounce or a 22 ounce or even perhaps a 26 ounce stick can be made but in every case, having very adequate balance between the various parts of the stick in weight and finally being sufficiently strong so that they will not readily fracture if subjected to impact at various parts against other sticks or the ground or other obstacles.

10 In the instance described, the total volume of plastics material has been reduced by approximately 20% by weight by reason of the gaseous infusion and the skin thickness in the embodiment has been at the lower end (that is around the hook) to be approximately 2 mm in thickness being the substantially consolidated part and up at the handle whereas the skin thickness has been still of approximately 2 mm, this has been reduced from a solid compacted material  
15 to one in which there is a substantial air infusion of approximately 5 to 10% of gaseous infusion.

The quantity of blowing agent into the plastics material can be varied and the range of perhaps 0.121% of blowing agent is possible although 0.25% by  
20 weight of the blowing agent has been a preferred quantity.

**CLAIMS:**

1. A hockey stick consisting of a head, a stem and a handle, comprised primarily of moulded plastics material manufactured as an integral whole or as a plurality of parts wherein at least two regions of the said hockey stick are characterised by each being of a different density one from the other and in which the density through the head and through the stem is characterised by being of greater density in an outer skin region than in a region contained by said outer skin.
2. The hockey stick of claim 1 wherein the rear of the stem of said hockey stick is characterised by one or more grooves.
3. The hockey stick of claim 2 wherein the said grooves are of 'U' shaped cross-section with a long axis of said groove running parallel to a long axis of the stem of the said hockey stick.
4. The hockey stick of claim 2 or 3 wherein the said grooves are moulded in the stem of the said hockey stick.
5. The hockey stick of any of claims 1 to 4 which includes a hollow core in the moulded plastics material or in a separately moulded plastics part.
6. The hockey stick of claim 5 wherein the said hollow core is contained primarily in the handle of the said hockey stick and is coaxial with a long axis of the said handle.
7. The hockey stick of claim 6 wherein the said hollow core is of substantially circular cross-section.
8. The hockey stick of any of claims 1 to 4 in which the handle of said hockey stick consists of a moulded shape interlocked, infused or surrounded by a further plastics material such that the said further plastics material provides a gripping shape by which the said hockey stick can be gripped.
9. The hockey stick of claim 8 wherein the said moulded shape is of a

star cross-section, or is a slot, or is of an elliptical cross-section, or is of a rectangular cross-section, or is of a triangular cross-section or is comprised of a plurality of circular apertures at spaced intervals along the said handle.

5 10. The hockey stick of any of claims 1 to 4 which includes an outer skin of said plastics material and a core comprised of a foamed plastics material.

11. The hockey stick of claim 10 wherein the said outer skin of plastics material of said hockey stick and the said foamed plastics material of the core of  
10 said hockey stick are of different chemical composition.

12. The hockey stick of claim 10 wherein the outer skin of plastics material of said hockey stick and the said foamed plastics material of the core of said hockey stick are of the same chemical composition but can be distinguished by  
15 the respective densities.

13. The hockey stick of any of claims 1 to 4 in which the said hockey stick is comprised of foamed said plastics material.

20 14. The hockey stick of any of claims 10 to 13 wherein the density of the said plastics material in the outer skin of the said hockey stick is greater than the density of the said plastics material in the core of the said hockey stick.

15. The hockey stick of claim 14 wherein the density of the said plastics material in the outer skin in the vicinity of the head and lower stem is greater and in the vicinity of an upper part of the handle is less than the average density of the outer skin.

16. The hockey stick of any of the preceding claims wherein the said  
30 plastics material is of the type known as thermoplastic.

17. The hockey stick of claim 16 wherein the said plastics material is nylon or polypropylene.

18. The hockey stick of any of the preceding claims in which the said  
35 plastics material is reinforced with randomly oriented fibre reinforcement.

19. The hockey stick of claim 18 wherein the said reinforcement is comprised of glass fibre.
- 5 20. The hockey stick of claim 18 or 19 wherein the length of the said fibre reinforcement lies within the range of 1 mm to 20 mm.
21. The hockey stick of claim 20 wherein the length of the said fibre reinforcement lies in the range of 4 mm to 12 mm.
- 10 22. The hockey stick of claim 21 wherein the length of the said fibre reinforcement has an average length of 8 mm.
23. The hockey stick of any of claims 18 to 22 wherein the total weight of said fibre reinforcement lies in the range of 60% to 90% of the total weight of said fibre reinforced plastics material.
- 15 24. The hockey stick of claim 23 wherein the total weight of said fibre reinforcement is 80% of the total weight of said fibre reinforced plastics material.
- 20 25. The hockey stick of any of claims 10 to 24 wherein the quantity of foam is sufficient such that the weight of the said foamed plastics material is reduced to 80% of that which would be the case if the plastics material were not foamed.
- 25 26. The hockey stick of any of the preceding claims in which at least in part the handle and the stem are wrapped with a material to aid the grip of a user of the hockey stick.
- 30 27. A hockey stick substantially as herein described with reference to and as illustrated by the accompanying drawings.
28. A method of manufacture of a hockey stick which comprises the steps of forming by injection moulding the said hockey stick comprising the steps of injecting into a mould a plastics material of a first selected density and incorporating at least one other area being of a density different to the said given density.
- 35

29. The method of manufacture of claim 28 wherein the said area of different density is formed by injection of a gaseous fluid for a selected period during the said step of injecting into a mould a plastics material.
- 5 30. The method of manufacture of claim 29 wherein the total weight of the said hockey stick is determined by the duration of the selected period of injection of the said gaseous fluid.
- 10 31. The method of manufacture of claim 28 wherein the said plastics material is a foamed plastics material.
32. The method of manufacture of claim 31 wherein the said foamed plastics material is formed by the inclusion of a foaming or blowing agent within the said plastics material before injection into the mould and said foamed plastics material is held under substantive pressure which is inherently lessened upon release into the said mould.
- 15 33. The method of manufacture of claim 32 wherein the foaming or blowing agent is known and sold under the trade mark "Hydrocerel".
- 20 34. The method of manufacture of any of claims 31 to 33 wherein the said foamed plastics material is gated into the injection mould at a location which comprises the inner part of the hook shape at the head of the said hockey stick.
- 25 35. The method of manufacture of any claims 32 to 34 wherein selected variations of the amount of said blowing agents results in selected variations in the weight of said hockey stick.
- 30 36. The method of manufacture of claim 28 wherein the said plastics material is of the type known as thermoplastic.



37. The method of manufacture of claim 36 wherein the said plastics material is nylon or polypropylene.

- 5 38. The method of manufacture of any of claims 28 to 37 wherein after manufacture the said hockey stick is immersed in water of a temperature in the range from 0° Celsius to 100° Celsius for a period sufficient to ensure a total take-up of water by said hockey stick.

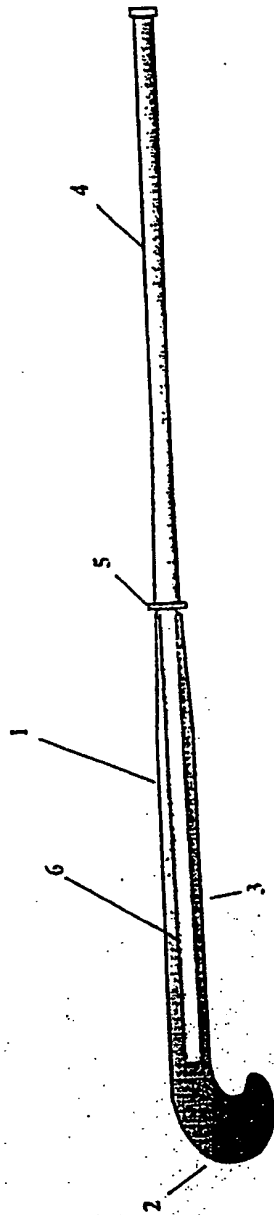


Fig 1

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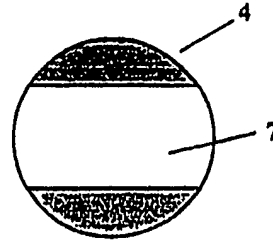


FIG 2

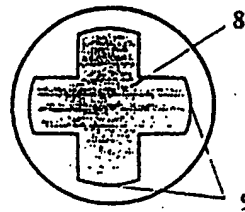


FIG 3

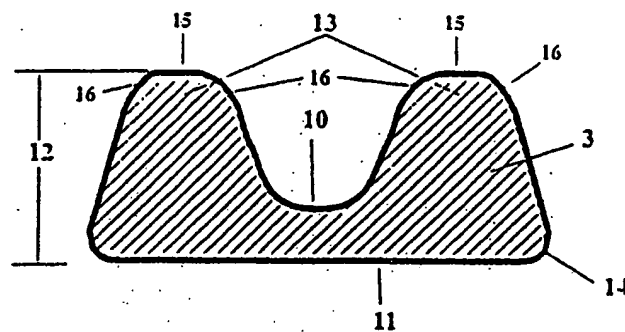


FIG 4

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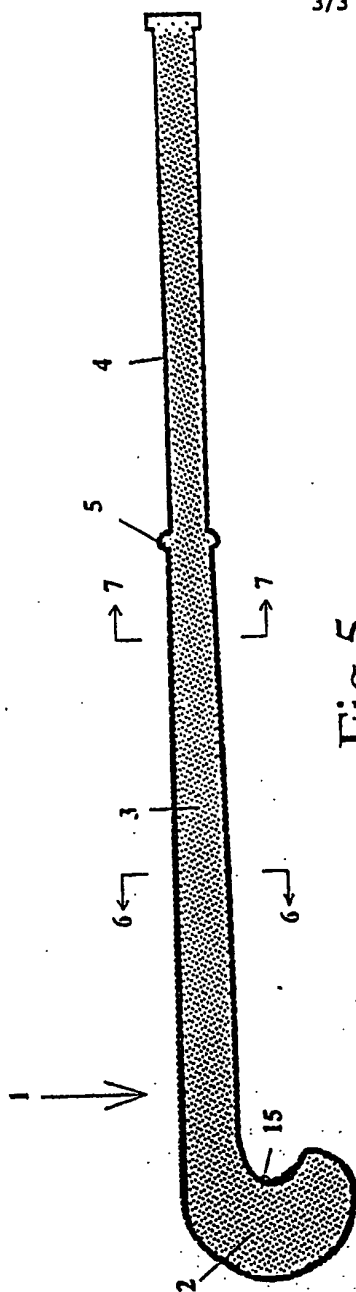


Fig 5

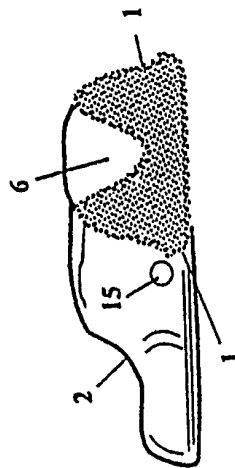


Fig 6

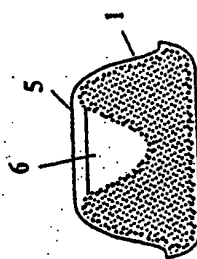
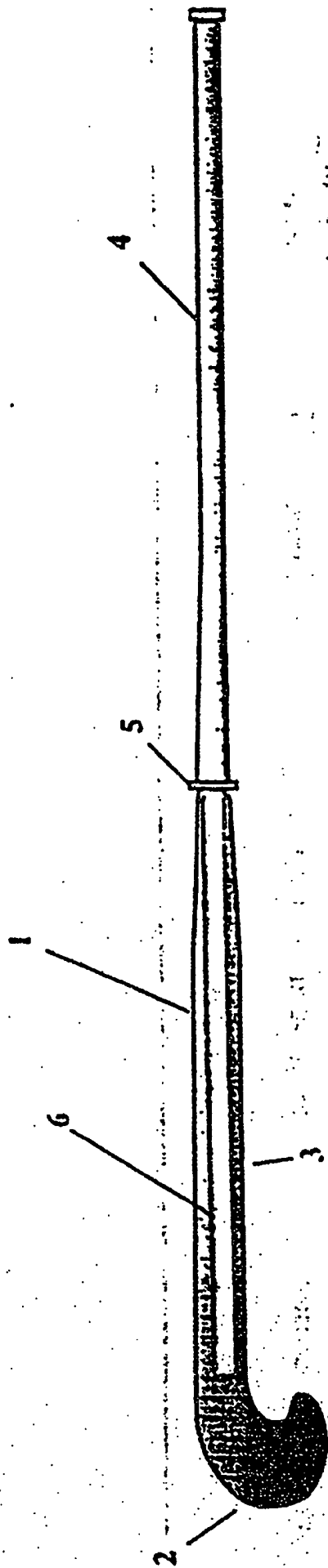


Fig 7

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